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(54) **Milling tool**

(57) A tool for milling grooves of semicircular cross section, more especially ball tracks of homokinetic joints, comprises a receiving shank 20, which is provided at the front end with a slot 24 which passes transversely therethrough and the flat walls of which are provided at an equal distance from the shank axis. A cutting bit 32, which has parallel and plane faces, is insertable into the slot and has a circumferential portion having an at least semicircular cutting edge 36,38 and a circumferential portion, contacting a surface forming the slot bottom. The bit is clamped in position between the slot walls by means of a clamping bolt 34. The cutting bit (32) consists of one piece and has cutting edges formed by edge portions (36, 38) of its projecting circumferential edges.

Fig. 1

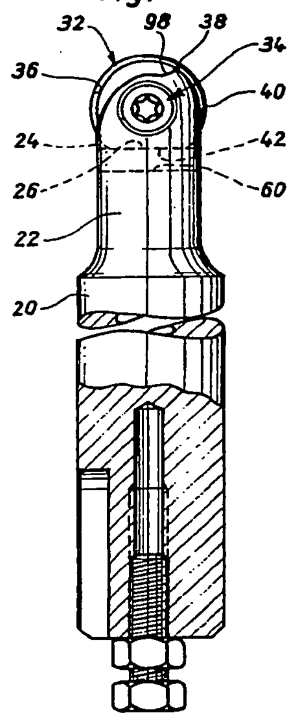

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Fig. 1

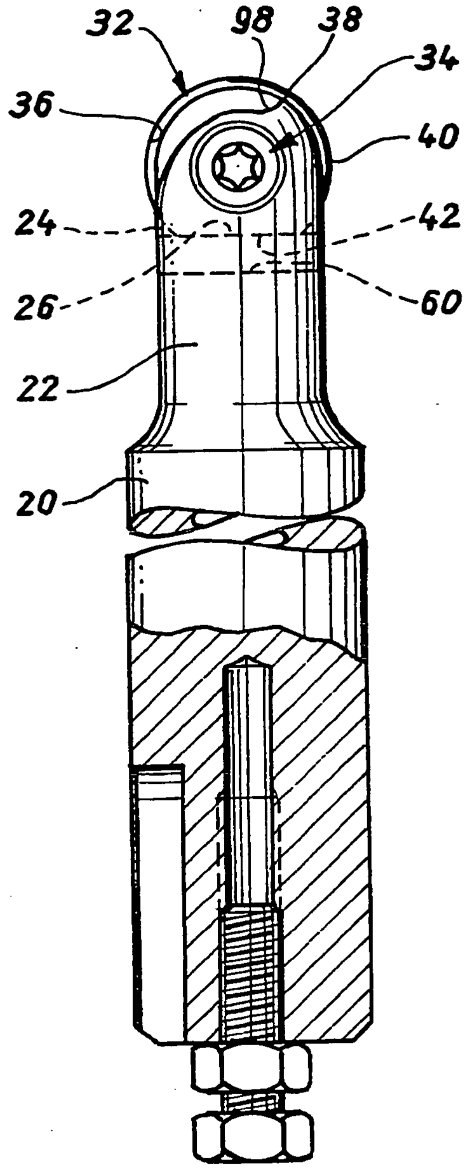


Fig. 3

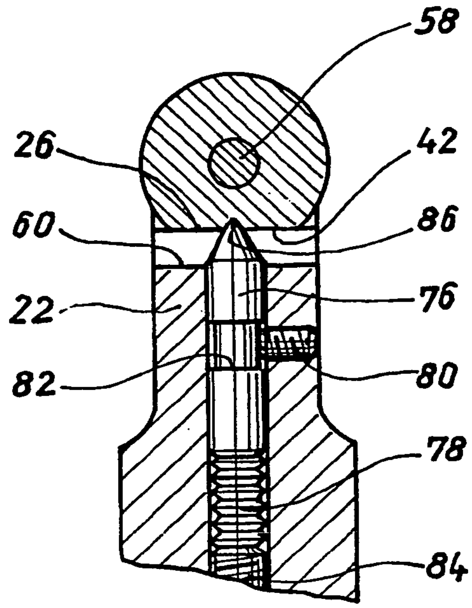


Fig. 2

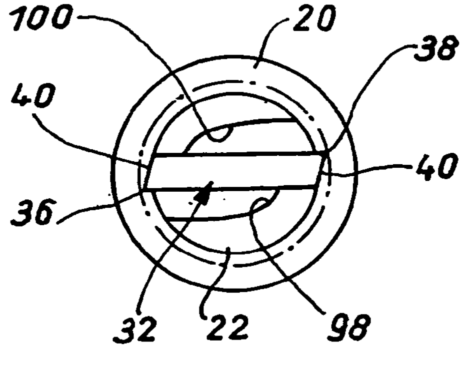


Fig. 4

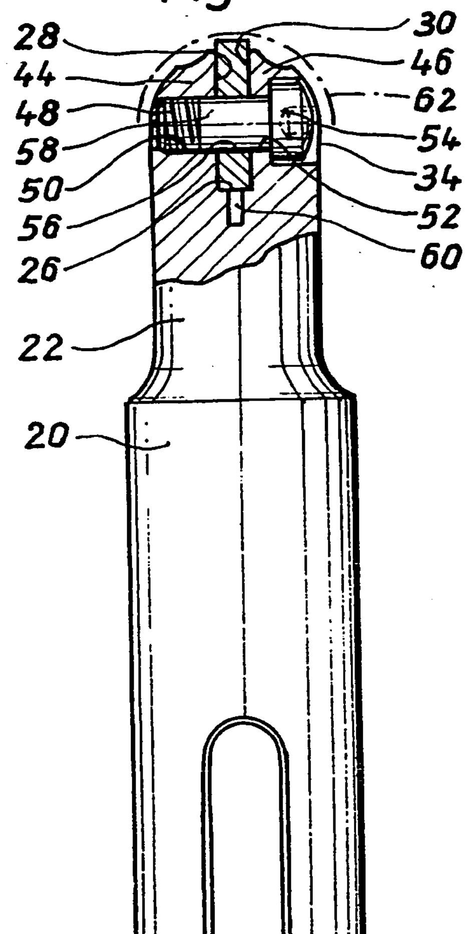


Fig. 5

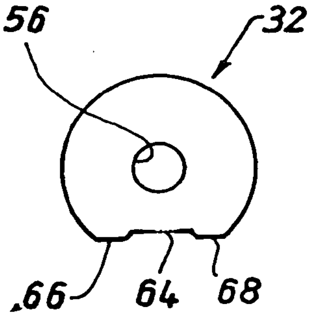


Fig. 6

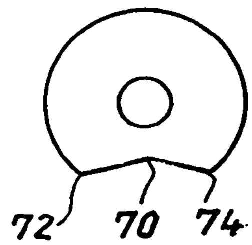


Fig. 7

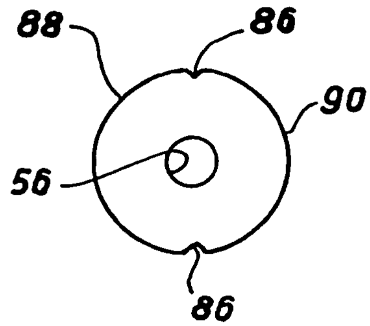


Fig. 8

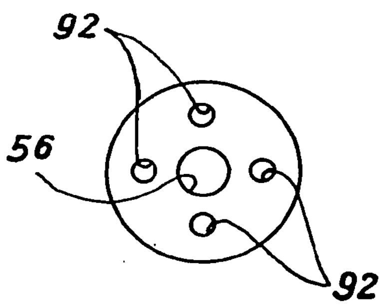


Fig. 9

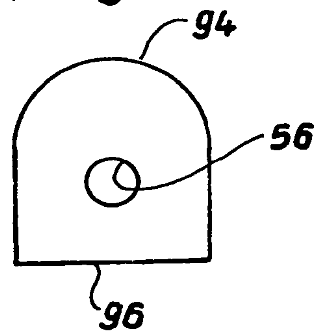


Fig. 10

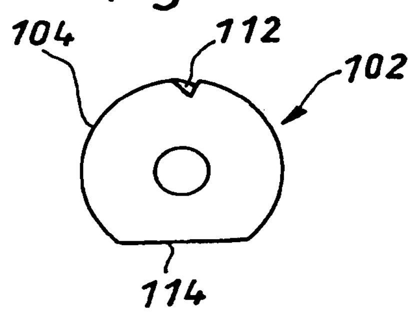
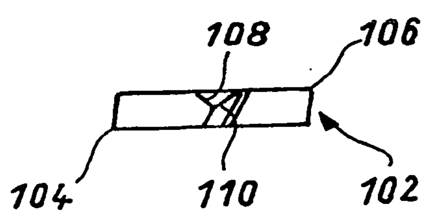


Fig. 11



SPECIFICATION

Milling tool

The invention relates to a milling tool for milling grooves of semicircular cross section, more especially ball tracks of homokinetic joints, the tool having the features described in the introductory part of Claim 1.

A milling tool having these features and intended for milling the grooves of homokinetic front-axle joints for motor vehicles is the subject matter of EP 0008972 A 1.

In the case of this milling tool, the circular cutting edge lies in a plane in which the rotation axis of the tool is also disposed. This results in the manufacturing advantage of allowing the circular cutting edge to be ground without any problems, in that grinding can be effected through the centre of the axis. There thus inevitably comes about a cutting edge run exactly along the contour of an eveloping ball.

This milling tool can be re-used in that the bit, when it has become blunt or defective, can be exchanged for an unused bit and can be subsequently reground.

However, serious disadvantages run counter to this manufacturing advantage.

The cutting edge run through the rotation axis can only be brought about in that the cutting bit is formed of or divided into two bit parts of equal thickness.

The bit division makes it however impossible to attain an absolute plane parallelism between the bit parts, particularly if the cutting bit diameter is relatively large. To attain this, it would be necessary, inter alia, that the axes of the bores of the two bit parts, which bores receive the clamping bolt, are absolutely normal to the faces, which is technically impossible in series production. In this connection, the existing deviations are added up so that double the tolerance occurs as the inaccuracy value. Furthermore, for the required accuracy, the plane contact surface formed by the slot bottom would have to be absolutely parallel to the clamping axis of the clamping bolt. Since this is not possible, these tolerances also double on account of the cutting bit division, the result being that the bit part having the largest dimensional variation determines the fixing, and consequently the total accuracy, of the tool and the clamping quality of the cutting bit in the tool holder.

Because of the inevitable inaccuracies resulting from the cutting bit division, the external faces of the two bit parts cannot, over the entire surface, be brought into contact with the slot walls in a plane-parallel manner. During the use of the milling tool, there therefore come about enormous forces of torsion along the clamping legs which hold the cutting bit and form the walls of the slot, intense vibrations resulting from these forces of torsion, causing clatter marks to be formed on the surface of the ball race grooves to be produced.

For reasons of strength, the cutting bit of this known milling tool cannot be produced with a radius which is smaller than approximately 10 mm because, if this were the case, the cross section of the two clamping legs would be so reduced that the required inherent rigidity of the receiving shank would no longer be ensured in the zone of its front end.

The uncontrollable vibrations make it furthermore impossible to produce the cutting bit from ceramic material.

The task underlying the invention therefore is to indicate a milling tool of the kind described at the beginning which renders possible a cutting bit design that is insensitive to vibrations as well as the exact locating in position of the bit in the slot of the receiving shank with a high accuracy of fit and the construction of which permits the radius of the cutting bit to be reduced to approximately 6 mm while the strength of the receiving shank remains unchanged in the zone of its front end.

According to the invention, this problem is solved in that the cutting bit consists of one piece and the cutting edge is formed by edge portions of its projecting circumferential edges which bound the faces and which extend towards the front into the zone of a plane which is normal to the slot walls and in which the axis of the receiving shank is disposed.

The bit cutting edge of the milling tool designed according to the invention is thus formed by parts of the circumferential edges which bound each face of the cutting bit. It is thus an eccentrically cutting bit which can be designed in one piece and can thus be given a surprisingly high degree of inherent rigidity. This design ensures the desired insensitivity to vibration.

The one-piece cutting bit furthermore renders possible the machining thereof within close tolerances and a correspondingly high accuracy of fit in the slot of the receiving shank as well as exact clamping between the clamping jaws forming the slot walls. In this connection, the gripping power is no longer of such importance as it is in the case of the known milling tool.

The bit cutting edges which are eccentric according to the invention present the further essential advantage that, due to the symmetrical centre offset thereof, these are of necessity given an additional clearance angle so that the clearance angle to be ground can be more obtuse and the cutting edge is by this means considerably stabilised. In this connection, there come about negative cutting geometries so that cemented oxides and sintered materials can be used for the production of the cutting bit.

When the cutting bit has become blunt or defective,it can be exchanged or rotated in the receiving shank after the clamping thereof has been released in order to bring into use another portion of the cutting edges formed integrally therewith. In this connection, it is possible to remove the cutting bit from the receiving shank and to turn it through 180° or to leave it in the shank and to rotate it to such an extent that a cutting edge portion that is still sharp will be in the position of the worn cutting edge portion.

The milling tool according to the invention may be provided with a single cutting edge which extends along a circular arc or with edge portions which form

symmetrical cutting edges which are disposed on the circumference of an enveloping ball.

As regards these cutting edge arrangements, it is of importance whether the milling tool is used for milling ball races in an axle journal bell or for milling ball races on the circumference of a ball hub. In the latter case, the centric cutting of one cutting edge is important, which means that during a rotation of the milling tool the respective cutting edge passes over the tool centre, so that in this case a special cutting edge configuration is necessary, and this in the manner of a boring or facing peeling-tool where the zone of the cutting centre of one of the two cutting edges lying on a circular arc is set back and is provided with a negative cutting rake. In this connection, attention must be paid that the rear of the centre portion is given a particularly large free space so as to keep the mechanical loading and development of heat as low as possible.

A wide variety of configurations is possible for the construction of the outer bearing and, in particular, the cutting bit itself may be so designed that, while being clamped in position, it sets itself automatically into an exact supporting position on the outer bearing.

In an advantageous further development of the outer bearing, this bearing comprises a supporting member which is displaceable against the action of an accumulator in the direction of the longitudinal axis of the receiving shank and which positively engages in a corresponding recess on the circumference of the cutting bit. This supporting member consequently inevitably also provides an exact alignment of the cutting bit in the slot during clamping.

The front end of the receiving shank is advantageously semispherical in design. Accordingly, provision must be made for it to be concentrically set back in the radial direction relative to the circular cylindrical circumferential shape of the cutting edge part of the cutting bit. In order to ensure a trouble-free chip formation and chip removal, a chip removal groove is integrally formed with the circumference of the semispherical shank front end partial piece which is located in front of each cutting edge of the cutting bit. It is furthermore favourable in this connection to finish the surface of the receiving shank, which may be effected with a hard chrome, titanium or carbon nitride coating so as to avoid any material abrasion caused by the accumulating chips.

Trials have shown that, with the milling tool according to the invention, it is possible to bring at least 30 cutting bits into use without any change of concentricity occurring or the receiving shank being impaired.

Further features and details of the invention will be illustrated in the following description of exemplified embodiments of milling tools according to the invention, which are shown in the drawings, and/or in the Claims. In the drawings:-

Figure 1 shows a side view of a first exemplified embodiment of a milling tool provided with a cutting bit that is clamped in position, in a shortened representation and partly in a longitudinal section,

Figure 2 shows a front view of the front end, which carries the cutting bit, of the milling tool shown in Figure 1,

Figure 3 shows a longitudinal section through the front receiving shank portion, which receives the cutting bit, of another exemplified embodiment of the milling tool,

Figure 4 shows a partial longitudinal section along the line 4-4 of Figure 3,

Figures 5 to *10* show various exemplified embodiments of cutting bits which can be clamped in position in the receiving shank, and

Figure 11 shows a top view of the cutting bit shown in Figure 10.

The milling tool shown in Figure 1 comprises an elongated cylindrical receiving shank 20, whose diameter has been adapted to the diameter of the respective spindle socket. In the zone of its front end, the receiving shank is reduced in diameter for the formation of a retaining head 22. The front end of this head is semispherical in design and is provided with a slot 24 which is passed transversely therethrough and which, as shown in Figure 4, is arranged so as to be symmetrical about a plane that is vertical on the longitudinal axis of the receiving shank in such a way that the bottom 26 thereof is vertical to the shank longitudinal axis.

A cutting bit 32 consisting of cemented carbide has been inserted in a precisely fitting manner into this slot, which comprises parallel walls 28, 30, and is held therein by means of a fastening device 34 in such a way that the contour of the semispherical front end of the retaining head 22 is arranged so as to be concentric with the circumference of the semicircular cutting bit and set back in the radial direction relative to the bit circumference.

The cutting bit has two cutting edges 36, 38 which, as shown in Figure 1, are symmetrically associated with each other when viewed in the direction of the longitudinal axis of the milling tool and are formed by the opposite circumferential edges bounding the bit circumferential surface.

For the formation of a clearance angle, the two cutting edges have been relieved by grinding on the bit circumference, the relieved surface 40, which is associated with the cutting edge 38, being visible in Figure 1.

The slot bottom 26 forms an outer bearing for fixing the cutting bit, which is an exchangeable bit in the present case, in the axial direction of the receiving shank in the retaining head 22. For this purpose, the cutting bit is provided on the circumference with a flat 42, with which it sits planely on the slot bottom and is kept in constant contact therewith under pressure by the fastening device 34.

The distance between the two slot walls 28, 30, which are arranged so as to be parallel to the rotation axis of the milling tool, is such relative to the thickness of the cutting bit that the latter can be fitted into the slot so as to be free from play and plane-parallel.

The two retaining head legs 44, 46 formed by the slot form a portion of the clamping device 34. So does a fastening screw 48 which can be screwed, vertically to the rotation axis of the milling tool, into a tapped hole 50 provided in the slot wall 28, for which purpose there is provided, coaxially with the

tapped hole 50, in the retaining head leg 46 a screw hole 52 which is spotfaced in sections so as to receive a screw head 54 of the fastening screw (Figure 4).

For the arrangement of the fastening screw, the cutting bit is provided with a central cylindrical recess 56, through which a cylindrical screw shank 58 engages.

The fastening screw is preferably a special screw which has been tempered to high strength and is provided with an internal Torx profile. The cylindrical screw shank 58 engaging through the cylindrial recess 56 in the cutting bit may be of a slightly eccentric design so that, when the fastening screw 48 is tightened for clamping the cutting bit in position between the retaining head legs 44, 46, there is previously generated a component of force in the axial direction of the receiving shank for locating the cutting bit in position on the outer bearing formed by the slot bottom 26. The reliable support of the cutting bit in the axial direction in the rear portion of the retaining head ensures that the cutting pressure is fully absorbed during the milling of ball tracks.

The clamping of the cutting bit can be furthermore enhanced by the provision of a relatively narrow slot 60 in the bottom 26, which slot extends through the entire retaining head. This additional slot reduces the contact surface of the outer bearing and ensures that the cutting bit support during the reciprocal bracing of the retaining head legs is effected in such a way that the fastening screw has to clamp the cutting bit only transversely of the axial direction of the receiving shank and furthermore to centre it on the axis of rotation.

The circular arc 62 shown in dash-dotted lines in Figure 4 illustrates a spherical envelope which is described by the cutting edges 36, 38 during the rotation of the milling tool.

Instead of a flat seating of the cutting bit on the slot bottom, the bit may sit thereon only sectionally. In the exemplified embodiment shown in Figure 5, the bit flat is for this purpose provided with a depression 64 so that the bit is supported on the slot bottom with two spaced supporting bases 66, 68.

In the exemplified embodiment shown in Figure 6, the cutting bit is provided on one circumferential part with a gable-roof-shaped depression 70 so that there are thus formed on the bit circumference at an angular distance two seating edges 72, 74 which serve for providing support on the outer bearing.

In the exemplified embodiment of a milling tool shown in Figure 3, there is located on the slot bottom, in the centre thereof, a projection which extends vertically to the axis of the fastening screw and which tapers in the direction of the fastening screw. This projection forms the end part of a pin 76 which is coaxially arranged in the receiving shank and is axially displaceable against the action of the Belleville spring set 78. The displacement path thereof is limited by a stop screw 80 which is radially arranged in the receiving shank and which projects into a pin circumferential groove 82 having a corresponding width.

The counterforce to be produced by the pin 76 and to be transmitted to the cutting bit can be set with the aid of a clamping screw 84 which is adjustably arranged in the receiving shank behind the set of Belleville springs. During the fitting of the cutting bit between the retaining head legs, the tapering pin end part engages in a central notch 86 in the bit flat 42 so that the cutting bit is received in a centring manner, during which process the pin, so as to allow the bit to be placed with a bias against the outer bearing or the slot bottom 26, will recede correspondingly against the action of the Belleville spring set.

In Figure 3, the milling tool has an exchangeable bit as the cutting bit. As shown in Figure 7, the bit may just as well be designed as a turnable bit. In this case, the cutting bit is of circular design and has on diametrically opposite places of the circumference corresponding engagement notches 86. Such a cutting bit can be used, for example, for milling in the ball tracks in axle journal bells, during which milling work the cutting edges 88, 90, which each extend over a zone of approximately 180°, do not have to cut centrically and there is consequently no need of a transverse cutting edge for cutting, which edge would have to lie in the zone of the engagement notches 86.

Figure 8 shows a constructional variant of a turnable cutting bit. This bit is also circular in design and is provided on one side surface with, for example, altogether four cams 92 which are located on a common circle, which is concentric with the centre of the cutting bit, at equal angular inervals. In this case, there should be provided, in a complementary arrangement, on one of the two slot walls 28, 30 corresponding depressions, into which these cams can be made to engage positively during the clamping of the cutting bit between the retaining head legs. In this case, too, intact cutting edges can be brought into use by rotating the cutting bit. These cutting edges extend - analogously to the construction shown in Figure 7 - over an angle of approximately 180°. Instead of the cams 92, there may be provided appropriate centres. Furthermore, the cams or centres may be provided on one of the retaining head legs 44, 46 and corresponding depressions may accordingly be provided in the cutting bit.

Figure 9 shows a cutting bit that is to be exchanged and also provides the possibility of regrinding. For this purpose, it is provided with a semicircular cutting edge 94 and the distance between the cylindrical recess 56 and the cutting edge is larger than the radius thereof. Opposite to the cutting edge 94, this cutting bit is provided, analogously to that shown in Figure 1, with a flat 96.

While the exchangeable bits shown in Figures 1 to 6 can be used only once, this exchangeable bit can thus be employed several times, regrinding being possible six to ten times depending on the given radial distance of the cutting edge 94 from the axis of the cylindrical recess 56.

As can be seen in Figures 1, 2 and 4, each retaining head leg is provided at the front end with a chip removal groove 98 or 100 extending over the zone of the adjacent cutting edge 36 or 38. Furthermore, at

least the retaining head legs and preferably the entire cylindrical retaining head and possibly a partial piece of the receiving shank are coated with, for example, hard chrome, titanium or carbon nitride so as to reduce the abrasion of material caused by the chips.

Figures 10 and 11 show a cutting bit 102 to be used as an exchangeable bit and having a cutting edge geometry which allows both the internal machining of an axle journal bell and the external machining of a ball hub of a homokinetic joint.

For this purpose, the cutting bit is provided with two cutting edges 104, 106, whose arrangement corresponds to that of the cutting edges 36, 38 of the cutting bit 32. Integrally formed wih the zone in which the cutting edge sections are which pass over the tool centre during the rotation of the milling tool are a transverse cutting edge 108 and a trailing cutting edge 110 which has to be disposed in front of the centre of the transverse cutting edge. The two cutting edges define a so-called stabilising bevel which is formed in the manner of a V-groove 112. This latter stabilises the milling tool during face cutting in that it is split in the manner of a boring or facing peeling-tool. This cutting edge geometry reduces the mechanical loading and also has an advantageous effect with respect to the development of heat.

Analogously to the cutting bit shown in Figure 1, the cutting bit 102 is provided with a flat 114. However, it may be designed as a turnable bit; in this case, it is provided with respectively one V-groove 112 at diametrically opposite points of the circumference.

CLAIMS

1. A milling tool for milling grooves of semicircular cross section, more especially ball tracks of homokinetic joints, the tool comprising a receiving shank, which is provided at the front end with a slot which passes transversely therethrough and the flat walls of which are provided at an equal distance from the shank axis, a cutting bit, which has parallel and plane faces and which is insertable into the slot in a fitting manner and which, with a circumferential portion which comprises an at least semicircular cutting edge, projects at the front end and at the circumference of the receiving shank and which, with a circumferential portion, can be placed against a contact surface forming the slot bottom and which can be clamped in position between the slot walls by means of a clamping bolt, for which purpose this bolt can be placed through a screw hole in one slot wall and through a central recess in the cutting bit and can be screwed into a tapped hole in the other slot wall, which tapped hole is aligned with the screw hole, characterised in that the cutting bit (32) consists of one piece and the cutting edge is formed by edge portions (36, 38) of its projecting circumferential edges which bound the faces and which extend towards the front into the zone of a plane which is vertical to the slot walls (28, 30) and in which the axis of the receiving shank (20, 22) is disposed.

2. A milling tool as claimed in Claim 1, characterised in that the edge portions (36, 38) of the cutting bit (32), which form the cutting edge, overlap at the tool front end.

3. A milling tool as claimed in Claim 1 or 2, characterised in that the zone of the cutting centre, located at the tool front end, of one of the two cutting edge portions (104 or 106) is set back and is provided with a negative cutting rake.

4. A milling tool as claimed in one of the preceding Claims, characterised in that the rear of the centre portion of the cutting edges (104, 106) has a relatively large relief-ground clearance.

5. A milling tool as claimed in one of the preceding Claims, characterised in that the contact surface (26) of the slot has a slot like depression (60) which extends over the entire length of the surface in parallel with the slot walls.

6. A milling tool as claimed in one of the preceding Claims, characterised in that the bit edge partial piece resting on the slot bottom (26) has a depression (64).

7. A milling tool as claimed in Claim 6, characterised in that the depression (64) provided in the cutting bit edge forms two spaced supporting bases (66, 68).

8. A milling tool as claimed in Claim 6, characterised in that the depression (70) provided in the bit edge is gable-roof-shaped.

9. A milling tool as claimed in Claim 6, characterised in that the bit edge partial piece having the depression is convexly curved in the circumferential direction and the depression is formed by an engagement notch passing transversely through the bit edge, and in that there engages positively in this notch a projection which is provided on the slot bottom (26) and extends vertically to the axis of the fastening screw (48).

10. A milling tool as claimed in Claim 9, characterised in that the projection forms the conically tapering end piece of a pin (76) which is coaxially arranged in the receiving shank (20, 22) and which is axially displaceable against the action of an accumulator (78).

11. A milling tool as claimed in Claim 10, characterised in that the bias of the accumulator, which is formed, more especially, by a Belleville spring set (78), is changeable.

12. A milling tool as claimed in one of the preceding Claims, characterised in that the cylindrical recess (56) passing transversely through the cutting bit (32) is concentric with the cutting edges which are disposed on an enveloping ball (62).

13. A milling tool as claimed in Claim 12, characterised in that the cutting bit forms a circular disc.

14. A milling tool as claimed in Claim 13, characterised in that the disc-shaped cutting bit is provided with respectively one engagement notch (86) at diametrically opposite circumferential parts.

15. A milling tool as claimed in Claim 13, characterised in that the disc-shaped cutting bit has at least at one bit side evenly angularly spaced projections (92) and/or depressions which, in the clamped condition of the cutting bit, are in positive engagement with corresponding parts of the receiving

shank (20, 22).

16. A milling tool as claimed in Claim 15, characterised in that the projections (92) and/or depressions are provided in a distributed manner on a circle that is concentric with the cylindrical recess in the cutting bit.

17. A milling tool as claimed in one of the preceding Claims, characterised in that the front end of the receiving shank (20, 22) is semispherical and in the radial direction is set back concentrically with the circular-cylindrical circumferential shape of the cutting part of the cutting bit (32).

18. A milling tool as claimed in Claim 17, characterised in that a chip removal groove (98 or 100) is integrally formed in the circumference of the partial piece, which is located in front of each cutting edge (36, 38) of the cutting bit (32), of the semispherical front end of the receiving shank (20, 22).

19. A milling tool as claimed in one of the preceding Claims 1 to 12, characterised in that the cutting bit circumferential part (94) comprising the cutting edges is semicircular and and in that the distance of the cylindrical recess (56) from this circumferential part is larger than the radius thereof.

20 A milling tool for milling grooves of semicircular cross section, more especially ball tracks of homokinetic joints, substantially as described herein with reference to the accompanying drawings.

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